New elements on Jules Regnault's *Calcul des chances et philosophie de la bourse* [*Calculation of the Chance and Philosophy of the Stock Market*]: a very well diffused book and new connections with Louis Bachelier

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Abstract
It is nowadays well-known that the first publication about the random character of stock market prices date back to 1863 with Jules Regnault's *Calcul des chances et philosophie de la bourse* [*Calculation of the Chance and Philosophy of the Stock Market*]. This book is the first work in modern finance we know today. Unfortunately, to date, we did not have significant information about the diffusion of this book and its influence. Recently several new elements have been discovered that change markedly what we thought we knew about Jules Regnault and about the dissemination and application of his ideas. This article presents and analyzes these new elements. It shows that this author grew up in an intellectual environment in Brussels closely associated with some of the most influent academics and mathematicians at this time. This article also shows that this book was largely diffused and more importantly it circulated among the most important French mathematicians interested in the application of the calculus of probability to finance and social issues when Louis Bachelier started his doctoral studies. This article sheds new light on the early history of financial economics and provides clear connections between Jules Regnault and Louis Bachelier.

1. Introduction
In 1863, Jules Regnault (1834-1894), a French broker's assistant [*employé d'agent de change*], published the *Calculation of Chance and Philosophy of the Stock Market*. It is a terrific book, which has a crucial place in the history of finance (Rutterford and Sotiropoulos 2015, Edlinger and Parent 2014, Szpiro 2011, Jovanovic and Le Gall 2001a, Jovanovic 2009, Taqqu 2001, Mehrling 2005, 2012), and also in the history of econometrics (Le Gall 2006, Jovanovic and Le Gall 2002). This book is the first work in modern finance we know today. It laid the foundations of modern stochastic models of asset price variations. For the first time the hypothesis of the random character of stock market prices is stated and validated by empirical data. Regnault also provided

the first asset pricing model such as those commonly used today. In this perspective, this book paved the way of modern finance.

This book is unique and contains many original ideas. It is extremely stimulating and very different from other financial publications of its time, which were interested in the way to make a fortune and rarely in a scientific analysis of financial markets. Precisely, until the 20th century, we do not know any equivalent of Jules Regnault's theoretical and quantitative approach of stock price variations in any other countries. Of course, some authors discussed financial concepts and strategies that are nowadays common, like the portfolio analysis based on the diversification strategy and correlation (Rutterford and Sotiropoulos 2015, Edlinger and Parent 2014). However, Regnault's approach was pioneering: his work took the shape of theoretical and mathematical models at a time when the application of statistics to the economic affairs was controversial in France. Moreover, no formal scientific community or discipline dedicated to "modern" financial analysis existed at this time. In this perspective, this book constitutes the first attempts known to construct a science of financial economics (Jovanovic 2002c, 2006c, b, 2009)[1].

Despite the importance of this publication, to date we didn't have significant information about this book and his author. Nothing new has been published since the rediscovery of the *Calculation of Chance* (Jovanovic 1998, Jovanovic and Le Gall 2001a) and the first biography on Jules Regnault (Jovanovic 2004, 2006b). Discovering new information is highly difficult. Several archives that could concern or concern Jules Regnault disappeared, and the only available starting point was one of his postal address. One of the main consequences of these lacks is that the *Calculation of Chance and Philosophy of the Stock Market* appeared as an isolated publication from an original speculator. In addition, this book looked disconnected with the rest of the history of economic ideas we know. For instance, because Louis Bachelier generally didn't give reference to other authors, even when he borrowed from them, the link between Jules Regnault and Louis Bachelier, the other key author of the early history of financial economics, still stays to be investigated (Jovanovic 2012, Taqqu 2001).

Recently several new information has been discovered about the education, the background and the networks of Jules Regnault and about the diffusion of his book[2]. These new elements change markedly what we thought we knew about this author and about the dissemination and application of his ideas. This article presents and analyzes these new elements, providing a rich history of the dissemination and application of Regnault's ideas.

The next section deals with Regnault's intellectual environment and background when he was a student. It analyses the elements newly discovered about his education and his networks. It shows that Jules Regnault grew up in an intellectual environment in which mathematics was important; it also explains that this could take advantage of powerful and international networks. The third section presents new crucial elements

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[1] In the same period, Henri Lefèvre also attempted to create a science of finance (Preda 2009, Jovanovic 2002a, 2006a, Zylberberg 1990).
[2] While I found most of the information presented in this article, several elements came from researches made by Pierre Driout on Jules Regnault in order to challenge the presentation made by Jovanovic (1998, 2002c, 2004) and Jovanovic and Le Gall (2001a).
I would like to thank Pierre Driout for our recent exchanges.

about the diffusion of the *Calculation of the chance* when it was published. We found at least two editions (and maybe three) and also an important book review showing that Regnault's book was known since it was published, and by some important authors of its time. The fourth section studies the circulation of the *Calculation of chance* among mathematicians. New elements show that the book quickly circulated among the main mathematicians interested in applying mathematics to finance and to social problems. This section shows a clear connection between Regnault's ideas and Louis Bachelier's work on finance. The fifth section analyzes the circulation of the *Calculation of chance* among economists. Although, academic economists refereed to the book after mathematicians, new elements point out its diffusion among some networks. This section shows in particular that Regnault and Bachelier were taught in the French universities and were part of a common knowledge among some French economists.

2. Regnault's intellectual environment

This section discusses Regnault's background and particularly the intellectual environment in which he grew up when he arrived in Brussels. Based on the information available, Jovanovic (2004, 2006b) supposed that Regnault's family had modest financial resources when he was in Brussels. However, elements recently discovered provide a very different picture.

First of all, it is worth reminding that Jules Regnault came from families of provincial dignitaries [notables de province]. The paternal family came from the Département de l'Aude (Maraye-en-Othe and Auxon); his paternal grandfather, Jean Baptiste François Regnault, was a bailiff (civil servant) married with the daughter of a surgeon. The maternal family came from the Département du Nord (Quievy); his maternal grandfather, Louis Haye, was a manufacturer and a property owner. Jules' father, Augustin Frédéric Regnault, was a military officer working for the Customs. He was based, at least at the beginning of his career, in the Département du Nord, around the city of Cambrai where he met his wife. When his father died on January 16, 1846, Jules was 12 years old and the family moved to Brussels.

This move to Brussels was crucial for Jules Regnault.
Firstly, he joined two of his uncles, Lucie Regnault (1811-1865) and Jean Baptiste Haye (1800- ?). We knew that both were professors: Jean Baptiste Haye, was teacher [maître d'études] at the beginning and then became language teacher in 1855; Lucie Regnault was professor, probably in history. However, to date we didn't know that Lucie Regnault was very well connected with Belgium high schools and universities. More precisely, he was the head of l'*Institution Regnault*, a private school [maison d'éducation] he created in the 1840s[3]. L'*Institution Regnault* was considered as "one of the most important institution of Brussels" (belge 1854, 162). In addition to this position, since 1853 he became the head of the *Ecole centrale de commerce et d'industrie*. This establishment deserves a more detailed analysis.

The *École centrale de commerce et d'industrie* in Brussel was one of the most important and prestigious high-schools and university colleges in Belgium during the 19th century. Like in France, the *Ecoles centrales* in Belgium were created in order to replace the old universities. For instance, the *École centrale de Bruxelles* replaced the

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[3] His brother-in-law, Louis Keyser, was head of a school too.

old *University of Leuven*, which was shut down in November 1797 after the session of the Austrian Netherlands to France. In the facts, the *Écoles centrales* replaced the university colleges from the former universities. However, by opposition to the university colleges, their programs focused on mathematics and sciences[4]. The *École centrale de commerce et d'industrie* had prestigious and influent professors, like the mayor of Brussels (Tilman 2006, 146). It was created in 1837 and aimed at educating students in sciences, particularly in mathematics:

> "Quand, en 1837, [fut créée] l'École centrale, il n'y avait, en Belgique, que des écoles primaires et des écoles latines. Il n'y avait qu'une seule voie pour s'élever par la science, et cette voie était longue et aride. Il fallait consacrer six à sept ans à l'étude des langues mortes, pour pouvoir aborder celle des sciences mathématiques ou des sciences naturelles. L'éducation était un contre-sens et un anachronisme" (De Brouckere 1847, 287)[5].

The *Ecole centrale de commerce et d'industrie* was created for educating the sons of manufacturers and traders; many politicians, businessmen, including bankers, and other influent persons were graduated from this institution (Tilman 2006, 146-8 and 163). There were around 265 students per year[6]. The students received a serious education in mathematics and sciences: they studied in particular Calculation of probabilities, Physics, Political economy, Algebra, Geometry (analytic and descriptive), Arithmetic. Interestingly, all of their disciplines constitute the foundations of the reasoning, demonstration and ideas used in the *Calculation of Chance*! Finally, it is worth mentioning that there was a close connection between the *Ecole centrale de commerce et d'industrie* and the *Athénée Royal de Bruxelles* where Adolphe Quetelet taught, because the *Ecole centrale de commerce et d'industrie* became the professional section of the *Athénée Royal*. The students of this *Ecole centrale* also followed some courses of the *Athénée Royal* (Tircher 1855, 252). Moreover, some professors taught in the two institutions. For instance, Morhange taught political economy in the two institutions. Here again we have a relevant connection, because Quetelet's ideas had a significant influence on Jules Regnault's methodology (Jovanovic and Le Gall 2001a, Jovanovic 2002c).

The *Ecole centrale de commerce et d'industrie* deserves our attention for another important reason. It is worth mentioning that at this time, Brussels was an important financial center. Moreover, by opposition to other countries at that time, Belgium was distinguished by the high level of training of people working in banks who were more frequently graduated from universities. More precisely, at this time, the training was

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[4] Students at the *École centrale de commerce et d'industrie* started at the age of 14 or 15 years. The five or six-year program was divided as follows: Preparatory studies (2 years); General Studies (3 years) and Application studies (1 year). The last grade (Application studies) was an optional year for preparing the first year of some engineer grades.
It is worth mentioning that after 1850 the programs followed the one established by the Belgium law of the 1st June 1840 (according tp the "section professionnelle des Athénées"). The five-year program was divided as follows: Preparatory studies (3 years); Advanced Studies (2 years).
[5] "when, in 1837, [it was created] there was in Belgium only primary schools and Latina schools. There was only one path to raise thanks to the science and this path was long and arid. We needed to dedicate six to seven years to the study to death languages before to study mathematics or natural sciences. Education was a non-sense and an anachronism".
[6] According to the ==Archives of the city of Brussels==, there were 271 students in 1848 and 264 in 1850. To compare, at this time, the most important high school, l'*Athénée Royal de Bruxelles*, had around 500 students.

4

strongly valuated among people interested in working in banks or finance in Belgium (Tilman 2006, 121; 136). In the mid-19th Century it became very popular for the future bankers be graduated from high schools specialized in business studies [études moyennes commerciales], the like the *École centrale de commerce et d'industrie,* which was the first one (and the only one until 1852) to offer such king of training (Tilman 2006, 146). For this reason, among the first students of the *École centrale de commerce et d'industrie* we found some of the most influent Belgium bankers and the first financial engineers in Belgium, like the Urban brothers, E. Godin, G. Brugmann (Tilman 2006, 146-148)[7].

Although we still didn't find (at least to date) element mentioning where Jules was educated, given that he was 12 years old when he arrived in Brussels, we can suspect that he studied in his uncle's school, *Institution Regnault*, and then at the *École centrale de commerce et d'industrie* managed by the same uncle. We already mentioned that the program of the latter was totally in line with Jules' knowledge; we can add that not only the program was but also the politic of the school, since we have several common ideas between Jules Regnault's book about the role of the science and the discourse for the graduation given by Morhange, the professor of political economy of the school. In this perspective, Regnault received a solid education.

Commenté [UMO1]: Il existerait une liste des élèves en 1851
Cf image00028.tif
En 1851, Jules avait 17 ans

In addition to this education, it is worth mentioning that, due to its importance and its prestige, the *Ecole centrale de commerce et d'industrie* attracted students from many countries, including, France, United Kingdom, United States, Luxembourg. Several students came from Paris and London, where were the two most important stock markets at this time. And several of the former students worked as bankers, politicians, etc. The *Ecole centrale de commerce et d'industrie* had also a powerful association of former students that maintained a strong network between these international students. Lucie Regnault, as head of the two prestigious schools, was a very influent person. He had conquered the trust of the dignitaries and aristocrats of Belgium (belge 1854, 162). He was also a member of the French education system (i.e. "membre de l'université de France"). Due to his positions, Lucie involved in important and powerful networks[8], particularly among academics, politicians and bankers. In other terms, Jules Regnault could take advantage to international and powerful networks interested in finance and well trained in the topic studied in the *Calculation of chance*.

As we understand, Jules Regnault grew up in an intellectual environment in which education and sciences were very important. His uncle, Lucie Regnault, had already published two books when Jules arrived in Brussels (Regnault 1841, 1842). This was a serious advantage for a new author, because he could receive personal advices and guidelines when he had to publish his own book. In this intellectual environment, mathematics was central. We already knew that Jules' brother, Odilon, studied advanced mathematics at the Université Libre de Bruxelles and that one of Jules' cousin, Albert Picard (the son of Jules' sister), was professor of mathematics in France

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[7] It is worth mentioning that the *Société générale* of Belgium was one of the first banks to hire engineers in 1867 (Tilman 2006, 126); this bank was also the second most important shareholders of the *Ecole centrale de commerce et d'industrie* (archives of the city of Brussels). Moreover, the Banque de Bruxelles which was created in 1871 with former students of the *Ecole centrale de commerce et d'industrie* had many engineers since its creation.
[8] For instance, he signed a petition in 1865 for the multilingualism in Belgium with very other influent academics (professors of universities, rectors, etc.).

(Jovanovic 2004, 2006b). Jean Baptiste was also associated with mathematicians. One of his witness at his marriage, Jean Louis Magnès, was a professor of mathematics. In addition, as the head of the prestigious *École centrale*, his second uncle, Lucie Regnault, knew several professors of mathematics, and of whom some of them were influent in their time. This point is important, because, as the section 4 will detail, the *Calcul des chances et philosophie de la bourse* was diffused among mathematicians at the beginning.

3. The large diffusion of the *Calculation of Chance* when it was published
This section analyzes the diffusion of the *Calculation of Chance and Philosophy of the Stock Market*. Such question is more complicate for an old book than for contemporary publications. First of all, several archives disappeared. In addition, many documents from libraries and archives are not digitized yet. Finally, the practices about citations have changed: it was common at Regnault time that authors did not cite or acknowledge the references they used; so, a book could have influenced authors while we cannot have a formal proof. Fortunately, new elements recently found change markedly what we thought we knew about the diffusion of the *Calculation of chance* when it was published.

Firstly, to date we didn't have information about the number of copies that were printed or sold because French archives about the number of prints disappeared. Despite this limit, we can claim today that the *Calculation of Chance* was very well sold. Indeed, it had several printings and at least two editions (and maybe three)[9]: I have found three different coverts of the book. While the publication date is the same (edition with Mallet-Bachelier was printed in 1862 although the date on the cover is 1863 and the legal depot was made in 1861), these coverts provide useful information on the diffusion of the book. The copies hold by the University of Leuven (Belgium) were edited by Castel solo and they mention that was a "new edition". The copies hold by the Library of the University of Toronto, Library of the Sapienza University of Rome, and the Library of the University of Kansas do not have the address of the author. Finally, contrary to the latter, the copies hold by the French National Library, the British Library and the Library of Congress were published by two editors, Castel and Mallet-Bachelier, and they also mention the address of the author. It was common at this time to print additional copies (generally around one hundred) including the address of the author in order to allow him to sell copies by himself[10].

This success is consistent with the fact this book was considered sufficiently important for the British Library, the Library of United States Congress, the Library of the University of Toronto, the Library of the University of Leuven (Katholieke Universiteit Leuven), the Wissenschaftliche Stadtbibliothek Mainz (a library of the city of Mainz created), Sapienza University of Rome (*Università degli studi di Roma « La Sapienza »*), the National library of Spain (Biblioteca Nacional de España), the John Crerar Library of the University of Chicago, the Cornell University Library to acquire copies[11]. Moreover, it is worth mentioning that the British Library acquired its copy in March 1864, less than sixteen months after his publication. Given the connection

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[9] Maybe three editions because there are at least two mentions about the book edited by Gauthier-Villars, and Gauthier-Villars was the successor of Mallet-Bachelier.
[10] Personal conversation with Norbert Verdier, historian of mathematics and publishing.
[11] We can suspect that in the future with the digitization of Library catalogs new copies will be discovered.

6

between Paris stock market and London stock market at this time (Neal 1990) on one hand, and the network of former students of the *Ecole centrale de commerce et d'industrie* from London on the other hand, we can suspect that Regnault's ideas were known in London.

Secondly, recently discovered two book reviews of the *Calculation of chance*, underlying the good reception of the book. Let me detail the first one here, the next section will come back on the second. Few months after the publication of the *Calculation of chance* a book review was published in one of the most important newspapers in France, *La Presse*, by Alfred Darimon who was an influent financial columnist and economist. In his book review, Darimon claimed:

> « Voilà un livre qui ne ment point à son titre. C'est l'application la plus ingénieuse qui ait été faite depuis longtemps de la théorie des probabilités, de cette science qui sert de trait d'union entre les sciences morales et les sciences mathématiques.
> L'auteur est doué d'un esprit d'analyse remarquable, et, si l'on ne partage point toutes ses conclusions, on est du moins forcé de rendre hommage à la sagacité avec laquelle il analyse et classe tous les faits auxquels donnent lieu les opérations boursières.
> […]
> Il est fort douteux, que l'ouvrage de M. J. Regnault convertisse personne ; la manie du jeu tient à des causes morales ; il faut autre chose que des calculs pour la détruire. La *Philosophie de la Bourse* n'en est pas moins une œuvre sérieuse ; quand même elle se bornerait à démontrer que les phénomènes qui paraissent être le plus dans le domaine du hasard sont soumis pourtant à des lois générales faciles à déterminer, ce travail n'en serait pas moins utile à la science, et, à ce titre, il mériterait d'être bien accueilli par les hommes de progrès » (Darimon 1863)[12].

It is noticeable that Darimon's review emphasized on two categories targeted by Regnault: scientists and learned people. It is also the *raison d'être* of the newspaper in which this book review was published. Indeed, *La Presse* is the first real modern newspaper in France (http://gallica.bnf.fr/blog/12122016/1836-naissance-de-la-presse-demile-de-girardin). His founder, Emile de Girardin, introduced a new model that completely changed the newspaper industry in France. In order to make the newspaper largely accessible (and not just an elite as it was the case before), the price was divided by two and advertisings were introduced (for compensating the smaller price). Without any doubt, such a book review led people interested in finance to pay attention to the *Calculation of chance*.

However, it is not the only point that deserves attention here. Alfred Darimon was an important figure at this time. When he started his career as a journalist, he was close

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[12] "Here is a book that does not betray its title. It is the most ingenious application of the probability theory (a science that makes a link between the moral sciences and the mathematical sciences) that had been made for a long time.
The author is gifted with remarkable analytical skills, and […] one has to pay tribute to the sagacity with which he analyzes and classifies all the facts that come from the trades on stock market.
The *Philosophy of the Stock Market* is a serious work. Even if it was limited to demonstrate that the phenomena that seem to be the most rooted with chance are nevertheless subject to general laws [,] it would not be less useful to science. As such, it deserves to be welcomed by the men of progress"

to Pierre-Joseph Proudhon. Then he became responsible for the economic issues in *La Presse* (F. Solar, *La Presse*, 16/02/1861). In addition to his journalism activities, he was a politician specialized in economic and financial issues. He was elected several times as a deputy of the National assembly. It is worth recalling that, when the *Calculation of chance* was published, there was many debates in France about the stock markets, particularly about their morality, and about the way to regulate some of their operations. These debates were often exposed in front of the courts, the National Assembly or the Senate (Riva and Lagneau-Ymonet 2011, Jovanovic and Le Gall 2001a, Tetreau 1994, Frèrejouan Du Saint 1893, Boboeuf 1864, Proudhon 1857, Bresson 1821). Economists were involved in these debates[13], and among the economists, Darimon was one of the most active. For instance, the year Regnault published his book, Darimon defended in front of the National assembly his opposition to the new conversion scheme to replace the 4.5% *Rente* (i.e. a French bond with a 4.5% interest) and the 4% *Rente* with the 3% *Rente* (Rietsch 2007). Darimon judged this scheme immoral because the French government acted like a gambler in order to increase the price of the *Rentes*! This position is very similar to Regnault's arguments. Because Darimon was deputy of the National assembly and because he shared some of Jules' ideas, we can suspect that the latter had an echo in front of the French National assembly and among some politicians. This seems highly possible because it is not the only element that connects Regnault's and Darimon. Both came from the Département du Nord, and so they could know each other before living in Paris. In addition, when Jules' bother, Odilon, died, his death was mentioned in *La Presse* (edition of the 20th of September 1871). This information underlines the link between Regnault's family and the newspaper *La Presse*, and maybe more specifically between Regnault and Darimon. Indeed, when Jules Regnault died, his death was not mentioned in the newspaper *La Presse*, and at this time Darimon was not active anymore.

This section shows that the *Calculation of chance* was known since it was published, and by some important authors at this time. In this perspective, it is worth mentioning that Darimon was also engaged in some debates with other economists who were interested in finance, like Léon Walras (F. Solar, *La Presse*, 16/02/1861). Consequently, a book review published by Darimon had necessary a large echo among people interested in finance.

4. The circulation of the *Calculation of chance* among mathematicians
This section analyzes new elements showing that the *Calculation of chance* quickly circulated among academics and mainly among some of the most important mathematicians interested in the application of mathematics to social issues. I mentioned that Jules Regnault grew up among mathematicians. He was also closed to his cousin Albert Picard who studied at the prestigious French *Ecole normale supérieure* and was also a professor of mathematics (Jovanovic 2004, 2006b). Jovanovic (2004, 2006b) already mentioned that the *Calculation of chance* received attention since the 1870s from some of the major French mathematicians interested in the calculation of probability applied to finance, particularly Laurent, Dormoy and Barriol. As Bru et al. (2012) and Le Ferrand (2014a) explained, these three

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[13] The *Journal des Economistes* —the most influential economic journal of the time— recurrently published debates among the members of the *Société d'Economie Politique* (see for instance the *Journal des Economistes*, 1857, 47, 308-14).

mathematicians worked together on mathematics applied to finance and insurance. As Le Ferrand (2014a, 5-6) pointed out, in the early years of the 1900s Laurent and Barriol taught modules dedicated to the application of mathematics to finance. In other terms, when Bachelier started his Doctoral thesis about the theory of probabilities, Jules Regnault's book circulated among the most important French mathematicians interested in mathematics, and particularly the theory of probabilities, applied to finance! It looks so obvious that when Barriol published his first (and only) book in 1908, which was a textbook on finance, *Théorie et pratique des opérations financières*, he linked the work of Regnault and Bachelier.

The second book review is another new element supporting the fact that the *Calculation of chance* circulated among mathematicians interested in applied mathematics to finance and to other social problems at the end of the 19th century (i.e. when Bachelier started his doctoral studies). In 1881, the Italian mathematician Angelo Paolini, professor of mathematics in Milano, also published a long book review (5 pages) of the *Calculation of chance* in the scientific journal *Annali di statistica* [*Annals of statitics*]. In 1880, this mathematician already published an *Essay of social arithmetic* [*Saggio di aritmetica sociale*], showing his interest for the application of mathematics to social sciences. This is in line with the fact that the *Calculation of chance* interested such mathematicians, like Piéron and Vaschide (1903) who cited Regnault's book and who were interested in the application of rigorous measurement techniques, in particular psychophysics, to social science topics from the viewpoint of mental activity[14]. This book review also shows that Regnault's work was diffused outside France soon after its publication.

This second book review deserves attention for another reason. Vinzenz Bronzin, another Italian mathematician, published eight years after Bachelier's *Theory of speculation* a "booklet" on the theory of premium contracts (i.e. option contract)[15]. Bronzin was professor of actuarial science at the *I.R. Accademia di Commercio e Nautica* in Trieste and published several books (Hafner and Zimmermann 2009, chap. 1). In his 1908 "booklet" (published in German), Bronzin analyzed premiums and developed a theory for pricing them. He started from the key hypothesis stated by Regnault and which was also the starting point of Bachelier: the random character of market fluctuations and zero expected profit. Bronzin showed that "applying Bernoulli's theorem to market fluctuations leads to the same result that we had arrived at when supposing the application of the law of error [i.e. the normal law]" (Bronzin 1908 in Hafner and Zimmermann 2009, 195). In other words, Bronzin used the normal law in the same way as Regnault since this law allowed him to determine the probability of price fluctuations (Bronzin 1908 in Hafner and Zimmermann 2009, 188). However, Bronzin did not refer to Regnault and Bachelier (keep in mind that extensive quoting was not common at this time).

Although Bronzin did not refer to Regnault and Bachelier, we have the same kind of network in Italy: mathematicians interested in mathematics applied to finance and

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[14] Pierre Driout found two other mentions of the *Calcul des probabilités*: in *Memorias de la Real Academia de Ciencia Exactas, fisicas y naturales de Madrid Par Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid* (vol. 30) published in 1923; and Tokei Kagaku Kenkyukai (1941) in the *Bulletin of Mathematical Statistics* (page 272).
[15] Premium contract (called "Prime") was a conditional forward contract close to option. Regnault and Bachelier dealt with *Prime* [Premium] contract (not with option contract).

social issues. It is worth reminding that at this time such a topic was not common. For instance, in France, the application of statistical procedures to the social sciences was controversial (Breton 1991, Ménard 1987, 1980) and statistics was even derided (Porter 1986, Le Gall 2006). New discoveries show that this interest for Regnault's work from mathematicians and statisticians interested in finance continued in France during the prolific period of the 1910s when the econometrics ideas emerged in this country (Le Gall 2006, Jovanovic and Le Gall 2001b). It was also during this decade that the distribution of stock prices (Gaussian or not) was intensively discussed among statisticians and mathematicians (Jovanovic and Schinckus 2017, chap. 1 and 2). A telling example of the interest of Regnault's idea by mathematicians and statisticians during this decade comes from Alfred Neymarck, a French economist and statistician and former president of the French society of statistics (Société de statistique de Paris)[16]. During the meeting of the 18th of February 1914 of the *Société de statistique de Paris*, Neymarck (1914) gave a long communication about the stock exchange. In this presentation, published in the journal of this scientific society, *Journal de la société de statistique de Paris*, he discussed Regnault's ideas. He claimed for instance that « Peut-on établir des règles de probabilités sur la hausse, la baisse, la stagnation des cours de telles ou telles valeurs? Je réponds très nettement non. Dans un livre paru, il y a cinquante ans [...] M. Regnault […] disait que les événements particuliers peuvent tromper les prévisions, mais qu'il faut savoir s'élever au-dessus de la considération de ces événements pour ne voir que l'ensemble des résultats derniers » (Neymarck 1914, 147)[17].

Neymarck was well known for his work on the stock markets since he started in the mid-19th century. To date, it is not possible to know if he knew Regnault's book before. However, his presentation was discussed by some of the members of the *Société de statistique de Paris*, including Alfred Barriol. This point is very important, because Barriol had just published in the *Journal de la société de statistique de Paris* a book review of Bachelier's *Calcul des probabilités* in which he strongly recommended to read the chapters dedicated to his theory of speculation (Barriol 1913). Another member of the *Société de statistique de Paris*, Lucien March, also had just published a book review on Bachelier's *Calcul des probabilités* in the *Journal de la société de statistique de Paris* (March 1912)[18]. Moreover, Barriol and March recommended Louis Bachelier as a new member of the *Société de statistique de Paris* in 1912. Therefore, when Neymarck's article was published in the *Journal de la société de statistique de Paris* in 1914, Bachelier was an active member of this society who already published in this journal. In addition, Bachelier was lecturer on "Probability Calculus with Applications to Financial Operations and Analogies with Certain Questions from Physics" in the Faculty of Sciences of the University of Paris. In this context, it looks clear that Bachelier knew Regnault's work (at least since 1910s). This also supports

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[16] He was also editor of the *Revue Contemporaine* in 1868-69, and in 1869 founded the newspaper *Le Rentier, journal financier et politique*, an economic and financial newspaper.

[17] "Can we establish probability rules on the rise, fall, stagnation of prices of such or such shares? I answer very clearly no. In a book published fifty years ago [...] Mr. Regnault [...] claimed that the particular events can deceive the forecasts, but we must know to rise above the consideration of these events in order to see only all of the last results".

[18] It is worth mentioning that Lucien March was an important mathematician who reshaped the French statistical system and who studied the distribution of prices (Jovanovic and Le Gall 2001b). One of his famous student, Marcel Lenoir, who was also a member of this society, studied the effects of stock-market fluctuations on economic activity during the 1910s (Jovanovic and Schinckus 2017, Chaigneau and Le Gall 1998).

the hypothesis that Bachelier knew the *Calculation of chance* during his doctoral studies although he didn't quote it in his doctoral thesis (Taqqu 2001, Jovanovic 2012, Ben-El-Mechaiekh and Dimand 2018). Indeed, Bachelier couldn't miss Neymark's comment about Regnault's book. However, when he published his last book about the theory de la speculation in 1938 he still not mentioned the *Calculation of chance*[19]. As Ben-El-Mechaiekh and Dimand (2018, 51) remind, "One can only be perplexed by Bachelier's choice not to refer to others' works […]. Much as in earlier work, the 1938 memoir is disconnected from both pre-1900 and post-1912 contributions" while it is obvious that he knew some of them[20]. Consequently, if Bachelier didn't refer to the *Calculation of chance* in his doctoral thesis it doesn't mean that he didn't know it at this time. Moreover, as mentioned, it was common at Bachelier's time that authors to not quote the references they used[21], and Bachelier adopted an extreme position because he almost referred to no others' works[22]. The hypothesis that Bachelier knew Regnault's book during his doctoral studies is also reinforced by another element.

It is worth mentioning that one of the editors of the book, Mallet-Bachelier, was one of the most important editors for mathematics and scientific books at this time (Verdier 2009, 2013)[23]. When he published the *Calculation of chance*, Alexandre Louis Jules Mallet succeeded to the founder of the editor (Charles Louis Étienne Bachelier), that became Mallet-Bachelier editor and significantly extended the production (Verdier 2009). Mallet-Bachelier was a reference at this time for books in mathematics and science. Two points deserve our attention here. Firstly, Alexandre Louis Jules Mallet was a provincial dignitary (judge) in Cambrai where Jules Regnault's father was based; so, their families could know each other. Secondly, in 1864 the editor Mallet-Bachelier became Gauthier-Villars (Albert Gauthier-Villars was Alexandre Mallet-Bachelier's son-in-law), which edited Louis Bachelier's thesis and book on the *Calcul des probabilités* (as well as Herman Laurent's *Traité du Calcul des probabilités* in which the Regnault's book in cited). The fact that Regnault and Bachelier had the same editor is a crucial information that links these two authors given the role of an editor for the authors[24].

To sum up, this section shows that the *Calculation of chance* was known by mathematicians interested in the application of mathematics to finance and social sciences. The fact that these works circulated among mathematicians interested in social issues, and not mathematicians in general, is interesting because "the prolific 1880-1910 period for the French school of mathematics with stars like Hermite, Poincaré, Picard, Cartan, Jordan, Borel, Lebesgue, Darboux, Baire, Hadamard and Lévy was followed by a lull in creativity during the second and third decades of the 20th

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[19] Ben-El-Mechaiekh and Dimand (2018) the first English translation of this book with a very exhaustive presentation of the context.
[20] "While mentioning "la loi de Gauss" in his thesis - but not in the 1938 memoir – Bachelier dos not refer to the prince of mathematics, Carl Friedrich Gauss himself" (Ben-El-Mechaiekh and Dimand 2018, 51).
[21] For instance, in finance, Bachelier and Barriol used Lefèvre's diagrams without acknowledgement.
[22] It is worth mentioning that Bachelier only refers to some mathematicians in his publications, although, as Ben-El-Mechaiekh and Dimand (2018, 51) reminded, "he was aware of what was being done in France and England". Ben-El-Mechaiekh and Dimand (2018) provide exhaustive explanations on this issue.
[23] The second editor, Castel, was one of the main editors, if not the major, of books about stock markets in France during the 1850s and the 1860s. Castel published in particular several of books of Louis Calemard de La Fayette including le *Guide du client à la bourse* (1859), which is cited by Regnault.
[24] Unfortunately, the archive of this editor does not exist anymore.

century. By then, the French have lost their supremacy, not only in mathematics but in all sciences, to the English and the Germans and to rising schools in Russia, Poland, Scandinavia, Hungary, and America. A reason for this decline is that unlike the UK, Germany, or Russia who elected not to send their scientists to the front, egalitarianism was the credo in France. Cohorts of graduates from the grandes écoles and universities were wiped out in the trenches" (Ben-El-Mechaiekh and Dimand 2018, 47). In other terms, Regnault's book circulated among a specific network, which was mainly the same as Bachelier. Consequently, the new elements discussed in this section reinforce the hypothesis that Louis Bachelier knew Regnault's book during his doctoral studies although he did not refer to it.

5. The circulation of *Calculation of chance* among economists
This section analyzes the circulation of *Calculation of chance* among economists. New elements recently discovered show that the *Calculation of chance* was known by French economists in the early 20th century who associated Bachelier and Regnault works about the random character of stock market prices.

We knew that Barriol was, among other things, the first professor of finance at the *Institut de Statistique* of the University of Paris, and that his textbook *Théorie et pratique des opérations financières* was used by generations of students in finance and insurance. We already knew that Alexandre Massebeuf (1923), a French economist used Regnault's ideas in his doctoral thesis defended at the Université de la Sorbonne (Jovanovic 2000), and that Julien Laferrière, who was professor at the Université de Lille and then at the Université de la Sorbonne, taught a course exclusively based on the work of Bachelier and Regnault (Jovanovic 2002b). We can show today that these authors were part of a same network.

Massebeuf defended his thesis in front of two of the most influent French economists at this time, Albert Aftalion and Bertrand Nogaro. Laferrière taught a doctoral course on finance at Université de Lille where he was professor in the same time as Aftalion[25]. Moreover, in the same period, the mathematician Robert de Montessus de Ballore was Maître de Conférences (i.e. associate professor) at the Lille Catholic University; he arrived in 1903, three years after Aftalion and five years before Laferrière. Montessus de Ballore was very familiar with Bachelier's *Theory of the speculation*, because his doctoral thesis supervisor, Paul Appell, was one of the examiners of Bachelier's doctoral dissertation[26]. Moreover, he defended his doctoral thesis in 1905 in front of his supervisor Paul Appell and also Henri Poincaré, who was Bachelier's doctoral thesis supervisor. In 1908, when Montessus de Ballore was professor at Lille, he published his book on probability theory entitled *Leçons élémentaires sur le Calcul des Probabilités* in which dedicated one chapter to Bachelier's Theory of Speculation. In other terms, in 1908 when Montessus de Ballore's book was published, Laferrière, Aftalion and him were all professors at Lille and they were all interested in mathematics applied to finance. It is worth mentioning that Montessus de Ballore discussed in 1908 with Barriol about the opportunity to create a permanent module dedicated to the application of mathematics to finance at the Université de la Sorbonne (Le Ferrand 2014a). Montessus de Ballore also had access to Hermann Laurent course notes (Le

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[25] Aftalion arrived in 1900 while Laferrière in 1908.
[26] It is worth mentioning that Hervé Le Ferrand, who is working on Robert de Montessus de Ballore, digitalized many of the archives of this author: http://leferrand.perso.math.cnrs.fr/.

Ferrand 2014a). Later, Montessus de Ballore became professor at the Université de la Sorbonne and Laferrière also moved in this university since 1929. So, they could keep contact. However, Montessus de Ballore didn't work anymore in finance because since the end of the first World War he changed fields[27], and thereafter published on statistics applied to meteorology (Ben-El-Mechaiekh and Dimand 2018, 46, Le Ferrand 2014b).

Consequently, we can claim that the financial theory of Regnault and Bachelier were taught in the French universities and were part of a common knowledge among some French economists. Despite this, finance didn't become a formal discipline at this time. As we know, the financial economics became a formal discipline in the 1960s in the United States (Dimand 2009, Fourcade and Khurana 2009, Poitras 2009, 2006, Jovanovic 2008, Davis and Etheridge 2006, Whitley 1986, Bernstein 1992). Although Bachelier's ideas were diffused among American economists only in the 1960s thanks to the American mathematician Jimmy Savage, they were always known by mathematicians (Ben-El-Mechaiekh and Dimand 2018, Jovanovic 2012, 2010, Davis and Etheridge 2006, Taqqu 2001); by contrary, Regnault's ideas didn't circulate among American economists when the financial economics was created. Consequently, it looks that, while Regnault and Bachelier's ideas were known by some economists they didn't create a research program in France. It is consistent with the state of the science in France after World War I. As we know, the history of financial economics is closely linked with the history of modern probability theory (Davis and Etheridge 2006, Jovanovic 2008, Shafer and Vovk 2001), to which it owes its major results, hypotheses and models. As Ben-El-Mechaiekh and Dimand (2018) reminded the French have lost their supremacy in all sciences because of the war, therefore, despite some academics still taught Regnault and Bachelier's ideas, the new ideas could not be developed. In addition, as Ben-El-Mechaiekh and Dimand (2018) explained there were several greatest missed opportunity for an earlier discovery by economists of Bachelier on the efficient market hypothesis, rational expectations, and stochastic processes (Keynes review, Levy's letter, French elitism system, etc.). It was only from the 1950s onwards that nonspecialists, and hence economists, began using the tools of modern probability theory: it was not until after World War II that the Kolmogorov's axioms became the dominant paradigm in this discipline (Shafer and Vovk 2005, 54-5). It is also after World War II that the American probability school was born in the United States. It was led by Doob and by Feller, both of whom cited Bachelier's work very early on[28]. As explained, Regnault's book that didn't have the same audience among mathematicians who developed the mathematical framework of the calculation of probabilities. Therefore, it could be not discovered by American economists in the 1960s. Moreover, the *Calculation of chance* was not diffused anymore in France, because the new generation of French academics and scientists interested in finance were trained in United States in order to import the new ideas from this country (Jovanovic and Numa 2018).

6. Conclusion
This article presents several new crucial elements for the history of financial economics that change markedly what we thought we knew about Jules Regnault and about the

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[27] He didn't find any academic position after the first World War (Le Ferrand 2014b, 20).
[28] Doob explained that he "started studying probability in 1934, and found references to Bachelier in French texts […] The ideas of Bachelier […] made a permanent impression on me, and influenced my work on gambling systems and later on martingale theory" (in Davis and Etheridge 2006, 92).

dissemination and application of his ideas. It explains that this author grew up in an intellectual environment in which education and sciences were very important. Moreover, he could take advantage of powerful networks interested in finance and in mathematics applied to finance. The article also shows that the *Calcul des chances et philosophie de la bourse* [*Calculation of the Chance and Philosophy of the Stock Market*] was well diffused at its time and circulated from the beginning among mathematicians interested in the applications of mathematics to finance and social issues. Then Regnault's ideas circulated among some important French economists and taught in some French universities. The article also presents new elements supporting the fact that Louis Bachelier knew Regnault's ideas where he started his doctoral dissertation.

References

Barriol, Alfred. 1908. *Théorie et pratique des opérations financières*. Paris: Doin.

Barriol, Alfred. 1913. "Calcul des probabilités par Louis Bachelier." *Journal de la société de statistique de Paris* 54:214-216.

belge, L'illustration. 1854. *Almanach National de l'illustration belge - 1855*. Bruxelles: Ch. Vanderauwera.

Ben-El-Mechaiekh, Hichem, and Robert W. Dimand. 2018. "Louis Bachelier's 1938 Monograph on the Calculus of Speculation: Mathematical Finance and Randomness of Asset Prices in Bachelier's later work." *Revue d'histoire des mathématiques* 24 (1):41-106.

Bernstein, Peter L. 1992. *Capital ideas : the improbable origins of modern Wall Street*. New York and Toronto: Free Press; Maxwell Macmillan Canada; Maxwell Macmillan International.

Boboeuf, Pierre-Alexis-Francis. 1864. *Marchés à terme. Pétition adressée au Sénat par M. Boboeuf pour rendre obligatoires les marchés à terme*. Paris: impr. de C. de Mourgues frères.

Bresson, Jacques. 1821. *Des fonds publics en France et des opérations de la Bourse de Paris (4ème édition)*. Paris: Bachelier, Painparré.

Breton, Yves. 1991. "Les économistes français et les questions de méthode." In *L'Economie politique en France au XIXe siècle*, edited by Yves Breton and Michel Lutfalla, 389-419. Paris: Economica.

Bru, Marie-France, Bernard Bru, and Salah Eid. 2012. "Une introduction analytique à la Théorie analytique. Hermann Laurent (1873)." *Journ@l Electronique d'Histoire des Probabilités et de la Statistique* 8.

Chaigneau, Nicolas, and Philippe Le Gall. 1998. "The French connection. The pioneering econometrics of Marcel Lenoir (1913)." In *European economists of the early 20th century. Volume 1: studies of neglected thinkers of Belgium, France, the Netherlands and Scandinavia*, edited by Warren J. Samuels, 163-189. Cheltenham: Edwar Elgar.

Darimon, Alfred. 1863. "Calcul des chances et philosophie de la bourse, par Jules Regnault." *La Presse - Mercredi 25 mars*.

Davis, Mark, and Alison Etheridge. 2006. *Louis Bachelier's Theory of speculation*. Princeton and Oxford: Princeton university press.

De Brouckere, Ch. 1847. "École centrale de commerce et d'industrie de Bruxelles." *Journal des instituteurs primaires*:287-291.

Dimand, Robert W. 2009. "The Cowles Commission and Foundation on the functioning of financial markets from Irving Fisher and Alfred Cowles to Harry Markowitz and James Tobin." *Revue d'Histoire des Sciences Humaines* 20:109-130.

Edlinger, Cécile, and Antoine Parent. 2014. "The beginnings of a 'common-sense' approach to portfolio theory by nineteenth-century French financial analysts Paul Leroy-Beaulieu and Alfred Neymarck." *Journal of the History of Economic Thought* 36 (1):23-44.

Fourcade, Marion, and Rakesh Khurana. 2009. "From Social Control to Financial Economics: The Linked Ecologies of Economics and Business in Twentieth-Century America." annual meeting of the SASE Annual Conference, Paris.

Frèrejouan Du Saint, Georges-Marie-René. 1893. *Jeu et pari, au point de vue civil, pénal et réglementaire, loteries et valeurs à lots, jeux de bourse, marchés à terme*. Paris: L. Larose.

Hafner, Wolgang, and Heinz Zimmermann, eds. 2009. *Vinzenz Bronzin's Option Pricing Models: Exposition and Appraisal*: Springer.

Jovanovic, Franck. 1998. "Hasard mécanique et accidents imprévisibles : la naissance de la théorie financière." Master, Université Paris 1 - Panthéon-Sorbonne.

Jovanovic, Franck. 2000. "L'origine de la théorie financière: une réévaluation de l'apport de Louis Bachelier." *Revue d'Economie Politique* 110 (3):395-418.

Jovanovic, Franck. 2002a. "Instruments et théorie économiques dans la construction de la "science de la Bourse" d'Henri Lefèvre." *Revue d'Histoire des Sciences Humaines* 7:41-68.

Jovanovic, Franck. 2002b. "La Loi Juridique et la Loi Scientifique de la Bourse par Julien Laferrière." *Revue d'Histoire des Sciences Humaines* 7:181-191.

Jovanovic, Franck. 2002c. "Le modèle de marche aléatoire dans la théorie financière quantitative."Ph. D. thesis, University of Paris 1, Panthéon-Sorbonne.

Jovanovic, Franck. 2004. "Eléments biographiques inédits sur Jules Regnault (1834-1894), inventeur du modèle de marche aléatoire pour représenter les variations boursières." *Revue d'Histoire des Sciences Humaines* 11:215-230.

Jovanovic, Franck. 2006a. "Economic instruments and theory in the construction of Henri Lefèvre's "science of the stock market"." In *Pioneers of Financial Economics, vol. 1*, edited by Geoffrey Poitras, 169-190. Cheltenham: Edward Elgar.

Jovanovic, Franck. 2006b. "A nineteenth-century random walk : Jules Regnault and the origins of scientific financial economics." In *Pioneers of Financial Economics, vol. 1*, edited by Geoffrey Poitras, 191-222. Cheltenham: Edward Elgar.

Jovanovic, Franck. 2006c. "Was There a "Vernacular Science of Financial Markets" in France during the Nineteenth Century? A Comment on Preda's "Informative Prices, Rational Investors"." *History of Political Economy* 38 (3):531-546.

Jovanovic, Franck. 2008. "The Construction of the Canonical History of Financial economics." *History of Political Economy* 40 (2):213-242.

Jovanovic, Franck. 2009. "Le modèle de marche aléatoire dans l'économie financière de 1863 à 1976." *Revue d'Histoire des Sciences Humaines* 20:81-108.

Jovanovic, Franck. 2010. The dissemination of Louis Bachelier's work in mathematics. In *Working paper*.

Jovanovic, Franck. 2012. "Bachelier: not the forgotten forerunner he has been depicted as." *European Journal for the History of Economic Thought* 19 (3):431-451.

Jovanovic, Franck, and Philippe Le Gall. 2001a. "Does God practice a random walk? The "financial physics" of a 19th century forerunner, Jules Regnault." *European Journal for the History of Economic Thought* 8 (3):323-362.

Jovanovic, Franck, and Philippe Le Gall. 2001b. "March to numbers: The statistical style of Lucien March." In *History of Political Economy, annuel supplement: The Age of Economic Measurement*, edited by Judy L. Klein and Mary S. Morgan, 86-100.

Jovanovic, Franck, and Philippe Le Gall. 2002. "Genèse et nature de la Théorie de la spéculation: les contributions de Louis Bachelier et de Jules Regnault à la théorie financière et à l'économétrie." In *Louis Bachelier, aux origines de la finance mathématique*, edited by Jean-Michel Courtault and Youri Kabanov, 165-202. Besançon: Presses Universitaires Franc-Comtoises.

Jovanovic, Franck, and Guy Numa. 2018.

Jovanovic, Franck, and Christophe Schinckus. 2017. *Econophysics and Financial Economics: An Emerging Dialogue*. New York: Oxford University Press.

Le Ferrand, Hervé. 2014a. Au sujet du mathématicien Hermann Laurent (1841-1908). *HAL archives ouvertes*.

Le Ferrand, Hervé. 2014b. Sur le fonctionnement du Journal de Mathématiques Pures et Appliquées entre 1917 et 1937 d'après des lettres inédites de Henri Villat à Robert de Montessus de Ballore. *HAL archives ouvertes*.

Le Gall, Philippe. 2006. *From nature to models: an archaeology of econometrics in France, 1830-1930*. London: Routledge.

March, Lucien. 1912. "Calcul des probabilités par Louis Bachelier." *Journal de la société statistique de Paris* 53:255-260.

Massebeuf, Alexandre. 1923. *Des marchés à primes dans les bourses de valeurs (Paris - Londres - Berlin)*. Paris: Garnier frères.

Mehrling, Perry. 2005. *Fischer Black and the Revolutionary Idea of Finance*. Hoboken: John Wiley & Sons.

Mehrling, Perry. 2012. "Financial Economics." In *Handbook of the History of Economic Analysis*, edited by Gilbert Faccarello and Heinz Kurz, forthcoming. Cheltenhem: Edward Elgar.

Ménard, Claude. 1980. "Three Forms of Resistance to Statistics: Say, Cournot, Walras." *History of Political Economy* 12:524-41.

Ménard, Claude. 1987. "Why Was There No Probabilistic Revolution in Economic Thought ?" In *The Probabilistic Revolution, vol. 2, Ideas in the Sciences*, edited by Lorenz Krüger, Gerd Gigerenzer and Mary S. Morgan, 139-146. Cambridge: MIT Press.

Neal, Larry. 1990. *The rise of financial capitalism: international capital markets in the age of reason*. Cambridge: Cambridge University Press.

Neymarck, Alfred. 1914. "Les beaux temps de bourse." *Journal de la société de statistique de Paris* 55 (3):112-150.

Poitras, Geoffrey, ed. 2006. *Pioneers of financial economics: Contributions Prior to Irving Fisher*. Vol. 1. Cheltenham, UK ; Northampton, MA: Edward Elgar.

Poitras, Geoffrey. 2009. "From Antwerp to Chicago: The History of Exchange Traded Derivative Security Contracts." *Revue d'Histoire des Sciences Humaines* 20:11-50.

Porter, Theodore M. 1986. *The rise of statistical thinking, 1820-1900*. Princeton, N.J.: Princeton University Press.

Preda, Alex. 2009. *Framing Finance: The Boundaries of Markets and Modern Capitalism*. Chicago and London: University of Chicago Press.

Proudhon, Pierre Joseph. 1857. *Manuel du spéculateur à la Bourse*. Paris: Garnier frère.

Regnault, Jules. 1863. *Calcul des chances et philosophie de la bourse*. Paris: Mallet-Bachelier and Castel.

Regnault, Lucie. 1841. *Précis historique, chronologique et géographique de l'histoire sainte*. Bruxelles: Tircher.

Regnault, Lucie. 1842. *Précis méthodique de l'histoire générale des peuples de l'antiquité*. Bruxelles: Tircher.

Rietsch, Christian. 2007. "Le « Milliard des Émigrés » et la création de la rente 3 %." In *Le marché financier français au XIXe siècle. Volume 2*, edited by Georges Gallais-Hamonno, 209-261. Paris: Publications de la Sorbonne.

Riva, Angelo, and Paul Lagneau-Ymonet. 2011. "Les opérations à terme à la Bourse de Paris au XIX siècle." In *Le capitalisme au futur antérieur: Crédit et spéculation en France. Fin XVIIIe - Début XXe siècles*, edited by Nadine Levratto and Alessandro Stanziani, 107-142. Bruylant.

Rutterford, Janette, and Dimitris Sotiropoulos. 2015. "Like the horses in a race':
  Financial diversification before modern portfolio theory." The 19th Annual
  Conference of the European Society for the History of Economic Thought
  (ESHET), Rome (Italy).

Shafer, Glenn, and Vladimir Vovk. 2001. *Probability and Finance: It's Only a Game!*
  New York: Wiley.

Shafer, Glenn, and Vladimir Vovk. 2005.

Szpiro, George G. 2011*. Pricing the Future : Finance, Physics, and the 300-Year
  Journey to the Black-Scholes Equation*. New York, NY: Basic Books.

Taqqu, Murad S. 2001. "Bachelier and his Times: A Conversation with Bernard Bru."
  Finance and Stochastics 5 (1):3-32.

Tetreau, François. 1994. "Le Développement et les Usages de la Coulisse aux XIXe
  et XXe Siècles."PhD dissertation, Université Paris II.

Tilman, Samuel. 2006. *Les grands banquiers belges (1830-1935). Portrait collectif
  d'une élite*. Bruxelles: Académie royale de Belgique.

Tircher, Imprimerie et librairie. 1855. *Almanach de poche de Bruxelles pour l'année
  1855*. Bruxelles: J. B. Tircher.

Vaschide, Nicolas, and Henri Piéron. 1903. "Les Applications du calcul des
  probabilités." *L'Enseignement mathématique* 5 (1-2):1-44.

Verdier, Norbert. 2009. "Le journal de Liouville et la presse de son temps : une
  entreprise d'édition et de circulation des mathématiques au XIXe siècle (1824-
  1885)." Doctorate, Université Paris-Sud 11.

Verdier, Norbert. 2013. "Éditer puis vendre des mathématiques avec la Maison
  Bachelier (1812-1864)." *Revue d'histoire des mathématiques* 19:41-107.

Whitley, Richard Drummond. 1986. "The Rise of Modern Finance Theory: its
  characteristics as a scientific field and connection to the changing structure of
  capital markets." In *Research in the History of Economic Thought and
  Methodology*, edited by Warren J. Samuels, 147-178. Stanford: JAI Press Inc.

Zylberberg, André. 1990. *L'économie mathématique en France 1870-1914*. Paris:
  Economica.